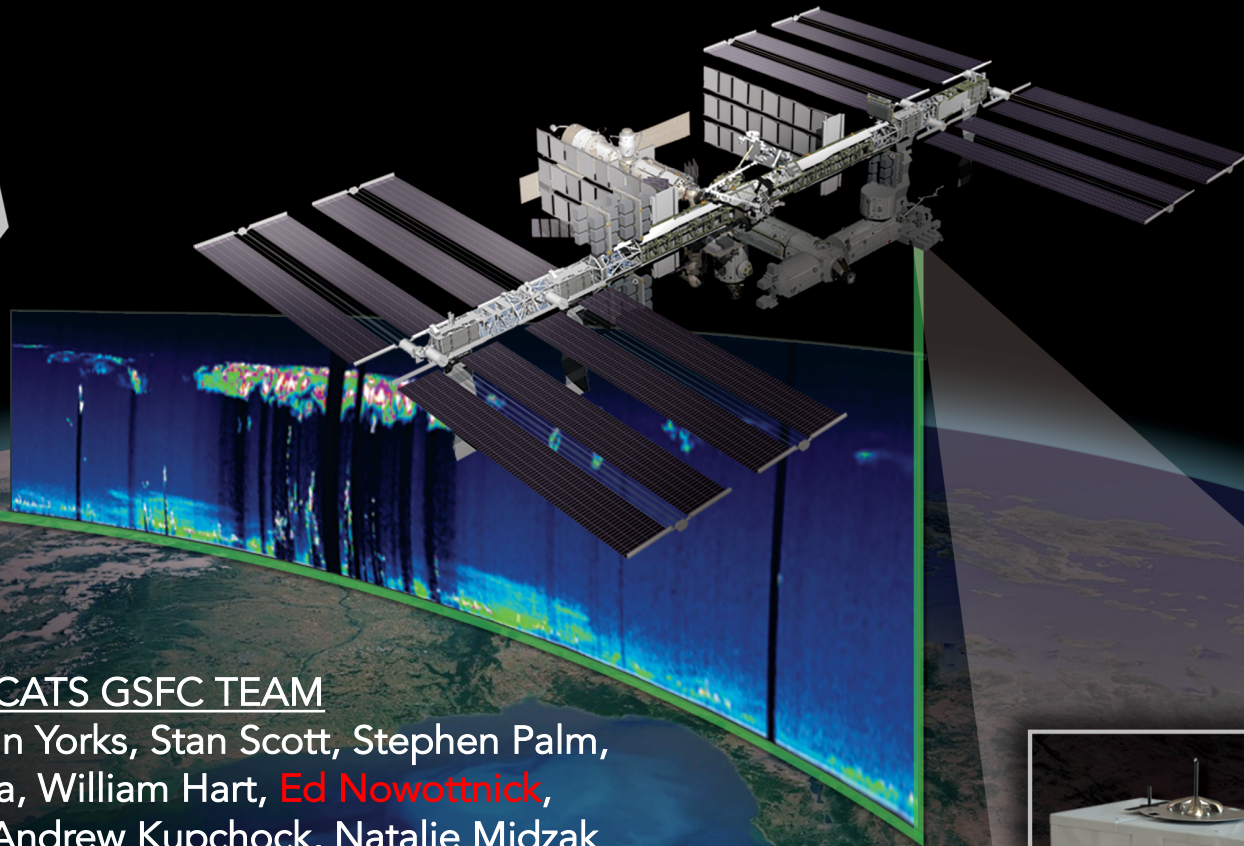


# CATS Aerosol Typing and Future Directions



## CATS GSFC TEAM

Matt McGill, John Yorks, Stan Scott, Stephen Palm,  
Dennis Hlavka, William Hart, **Ed Nowottnick**,  
Patrick Selmer, Andrew Kupchock, Natalie Midzak

## CATS LaRC Team

Chip Trepte, Mark Vaughan, Sharon Rodier, Tim Murray, Mike Jensen

## NASA GEOS-5 Collaborators

Peter Colarco, Arlindo da Silva, Virginie Buchard-Marchant



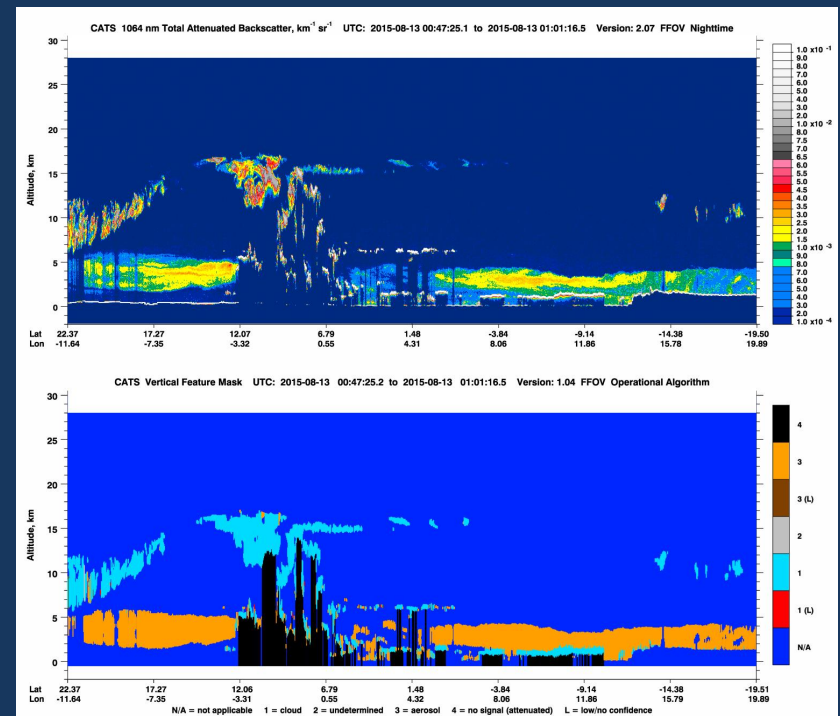
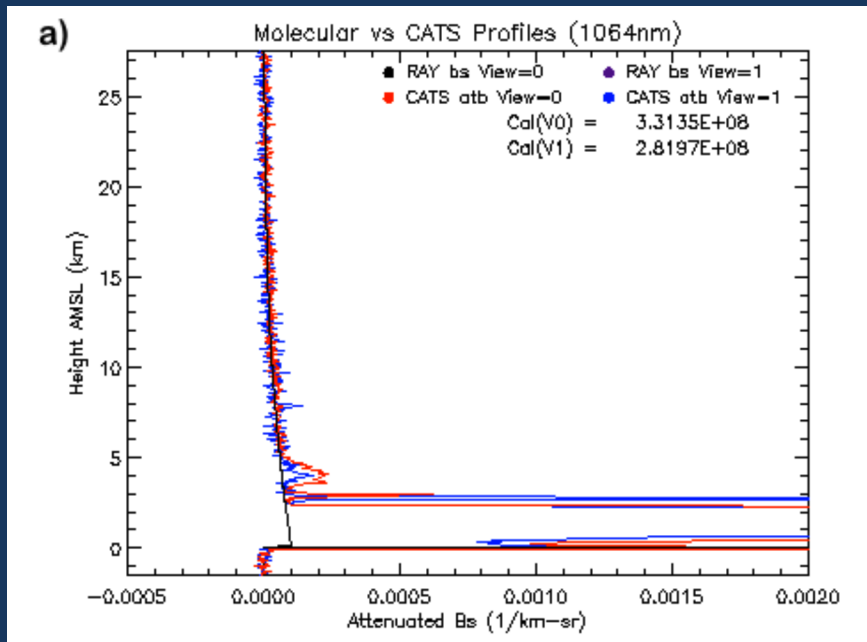
# Overview

- CATS Mode 2 Aerosol Typing Algorithm
- Case Studies
- Known Issues, Challenges and Current Efforts
- CATS Mode 1 Aerosol Typing Algorithm
- Future Plans
- Getting CATS Data

# Why do we need aerosol type?

- An extinction to backscatter ratio (lidar ratio) is needed to derive extinction products from observed backscatter.
- For standard backscatter lidars like CATS, lidar ratios are assigned for aerosol types.

1. The CATS feature detection algorithm first looks for regions of enhanced attenuated scattering ratios (observed to molecular) within a 5 km averaged profile.
2. Aerosol features are discriminated from cloud features using layer integrated total attenuated backscatter, integrated depolarization ratio, temperature, thickness, and color ratio (Mode 1 only).



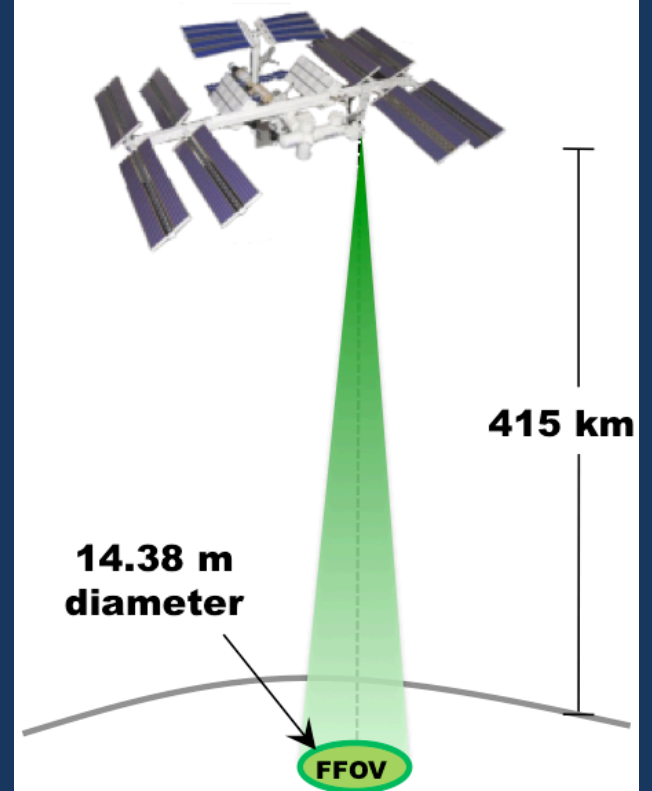
# CATS Mode 2 Aerosol Typing Overview

- Backscatter and Depolarization Ratio at 1064 nm
- Backscatter at 532 nm is very noisy and is not used in the algorithm
- For our version 1 Mode 2 aerosol typing, we rely on heritage from CALIOP

| Aerosol Type         | 1064 nm Lidar Ratio |
|----------------------|---------------------|
| Marine               | 45                  |
| Dust                 | 55                  |
| Dust Mixture         | 45                  |
| Clean/Background     | 35                  |
| Polluted Continental | 35                  |
| Smoke                | 40                  |
| Volcanic Sulfate     | 35                  |

## Mode 2: Laser 2

Backscatter: 532, 1064 nm  
Depolarization: 1064 nm  
L2 Products: 1064 nm



**Semi-continuous operation:**  
**25 Mar. 2015 – Present**



# CATS Mode 2 Aerosol Typing Overview

- Backscatter and Depolarization Ratio at 1064 nm
- Backscatter at 532 nm is very noisy and is not used in the algorithm
- For our version 1 Mode 2 aerosol typing, we rely on heritage from CALIOP

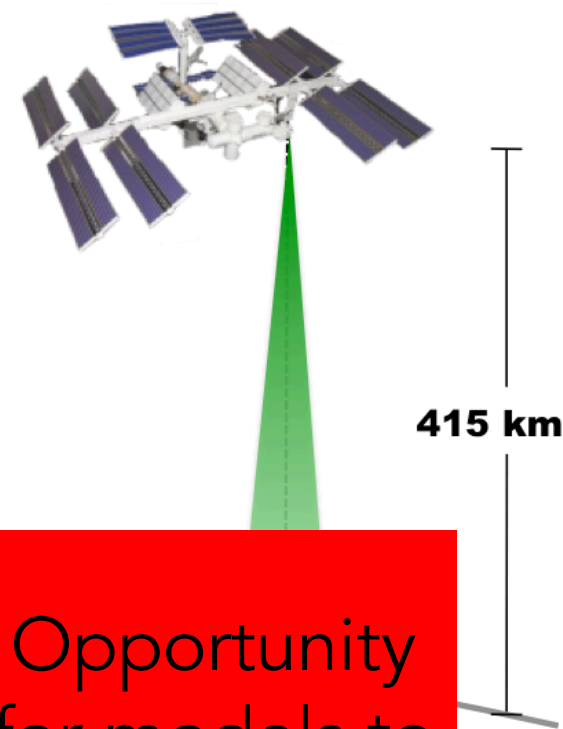
| Aerosol Type         | 1064 nm Lidar Ratio |
|----------------------|---------------------|
| Marine               | 45                  |
| Dust                 | 55                  |
| Dust Mixture         | 45                  |
| Clean/Background     | 35                  |
| Polluted Continental | 35                  |
| Smoke                | 40                  |
| Volcanic Sulfate     | 35                  |

## Mode 2: Laser 2

Backscatter: 532, 1064 nm

Depolarization: 1064 nm

L2 Products: 1064 nm



Opportunity  
for models to  
help

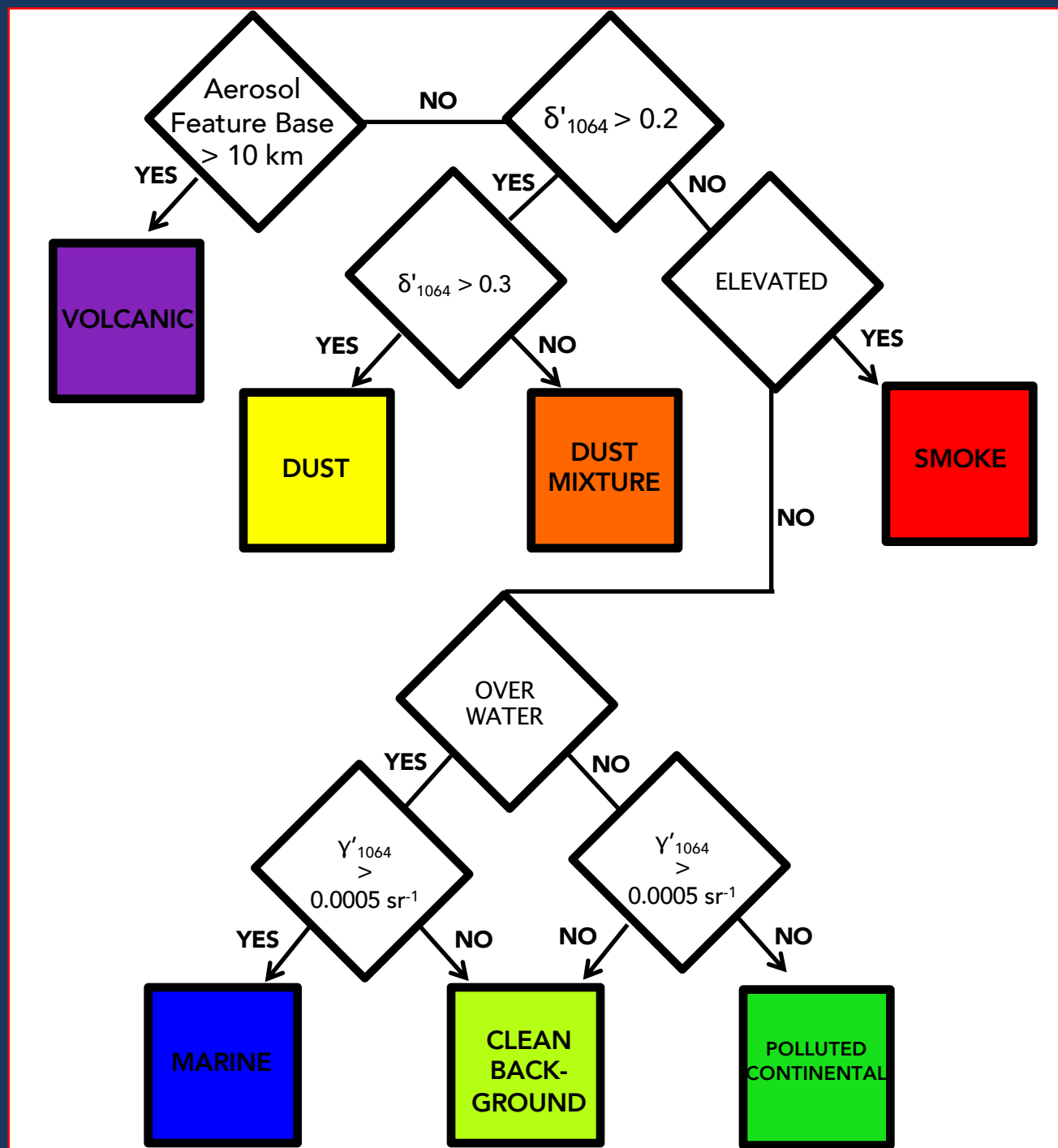
ion:  
ion:

# CATS Mode 2 Aerosol Typing Algorithm

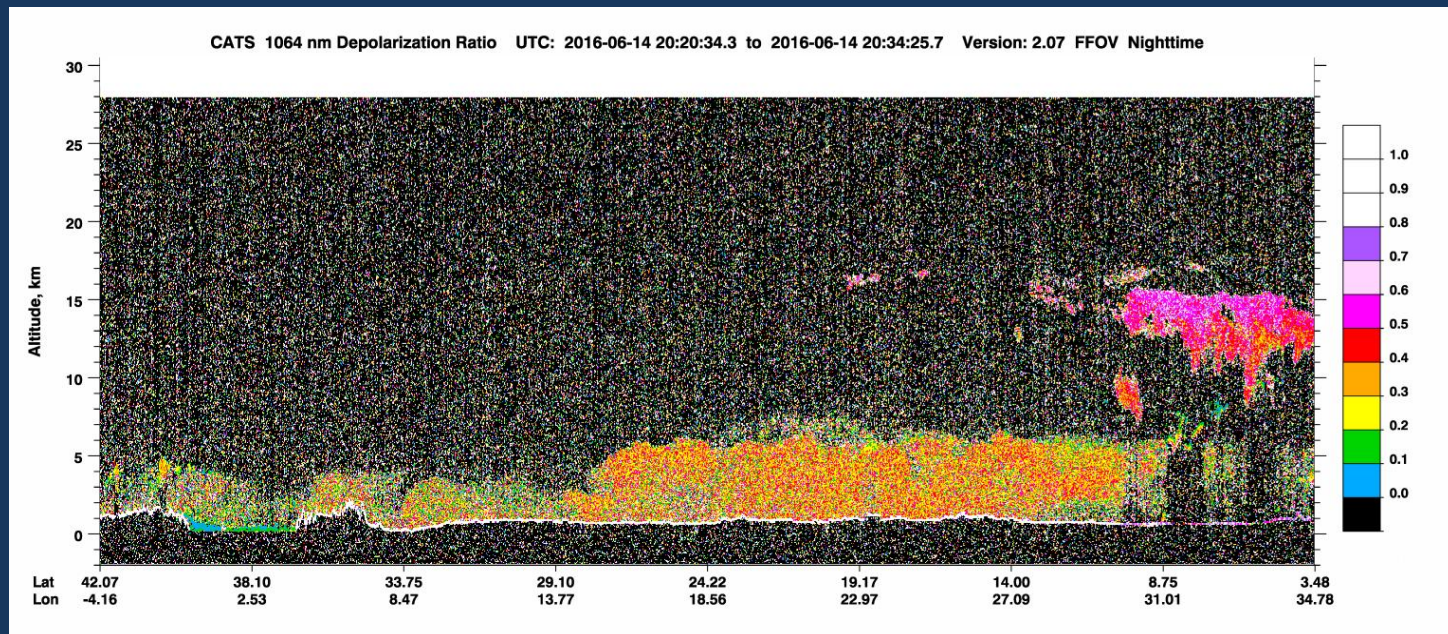
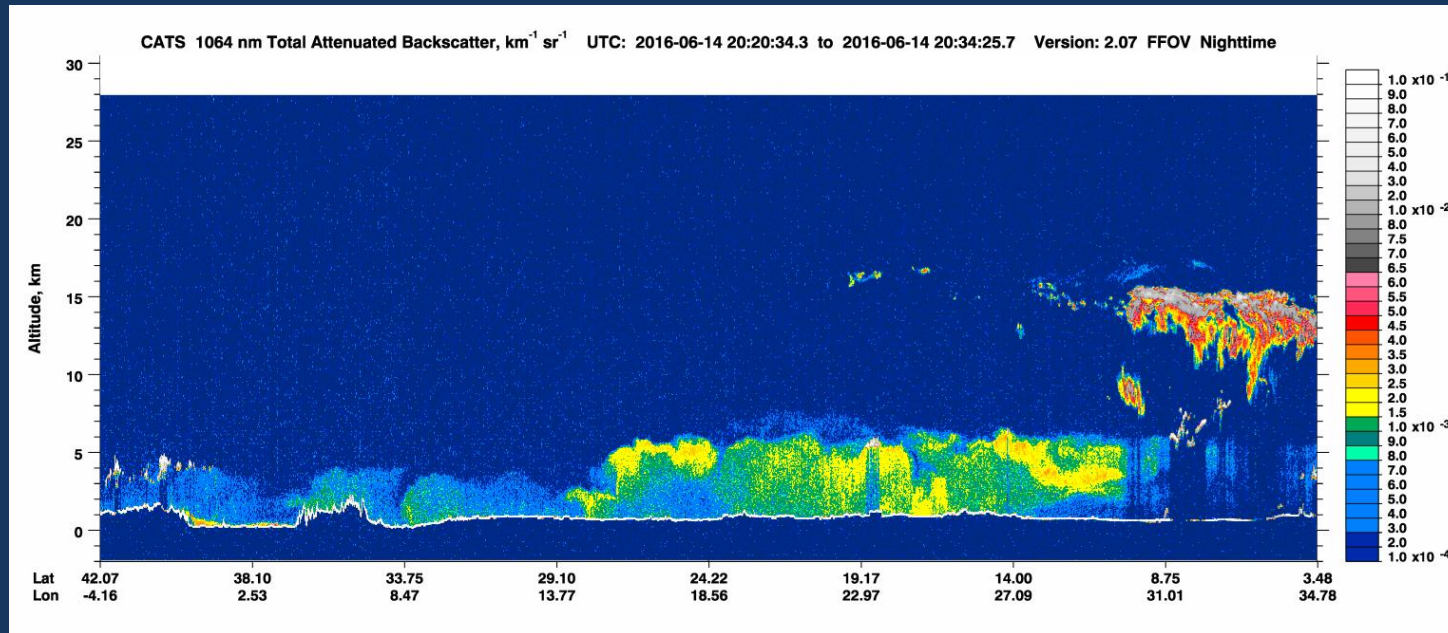
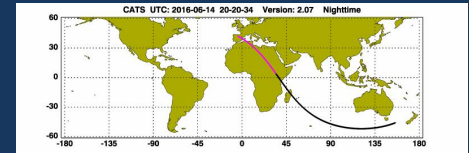
## Inputs:

- Feature Integrated Depolarization Ratio at 1064 nm ( $\delta'_{1064}$ ) averaged to 5 km horizontally
- Feature Integrated Total Attenuated Backscatter at 1064 nm ( $\gamma'_{1064}$ ) averaged to 5 km horizontally
- Surface Type (for maritime)
- Feature Altitude

\* Heritage from CALIOP aerosol typing algorithm

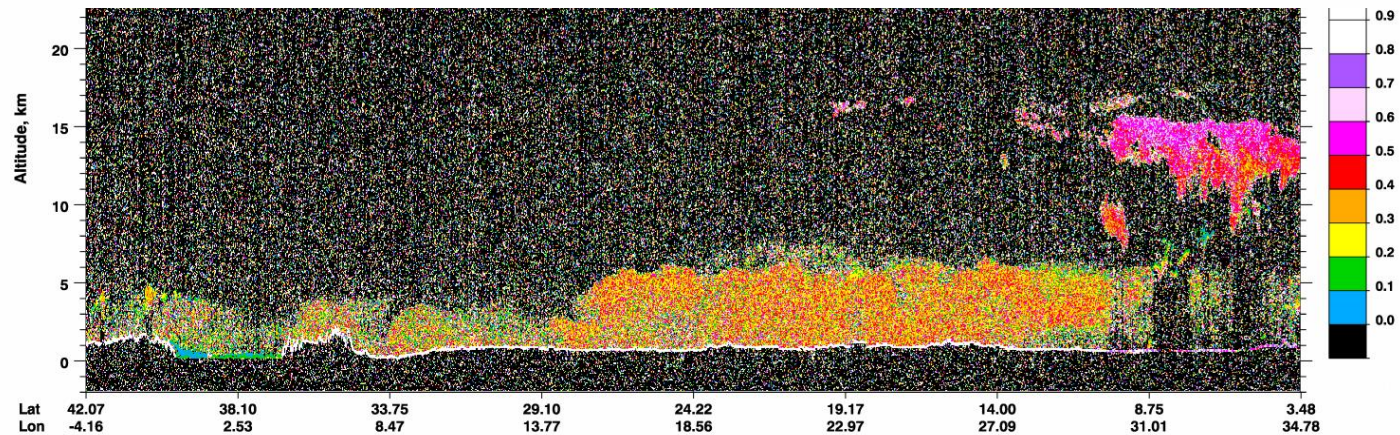
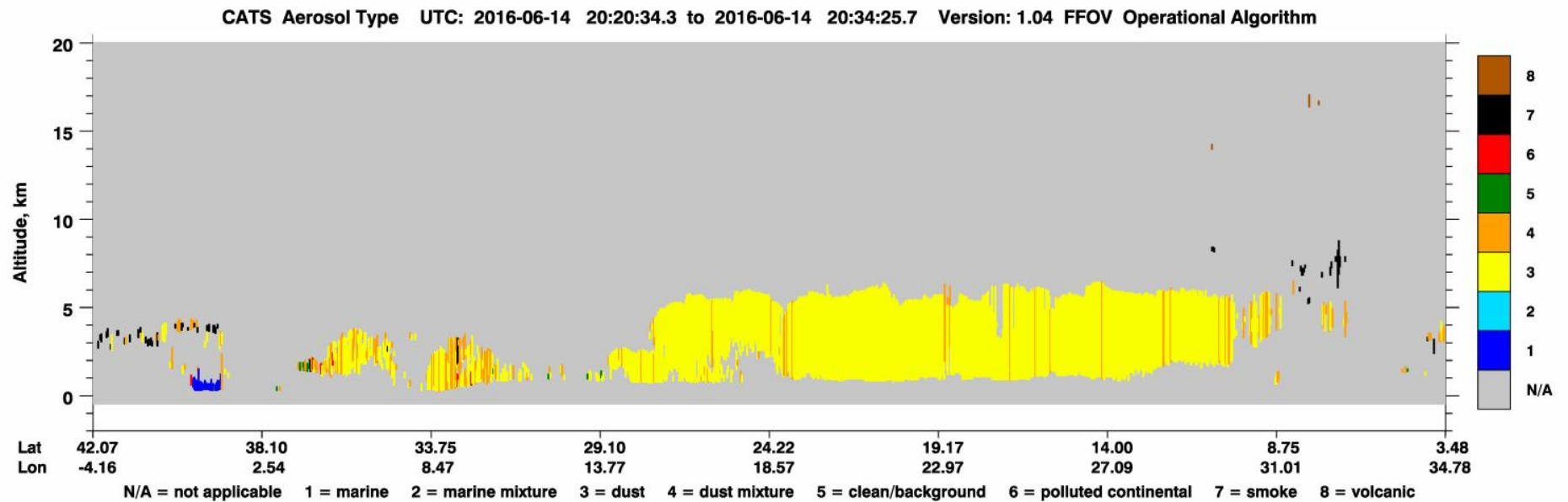
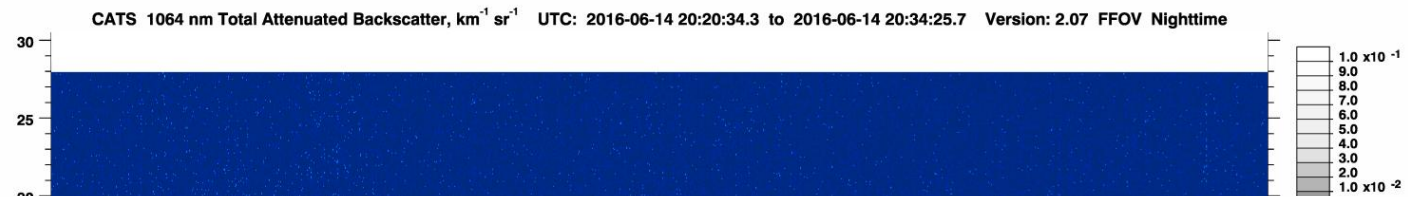
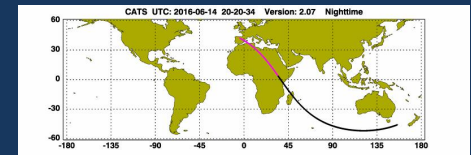


# Case Study: Saharan Dust



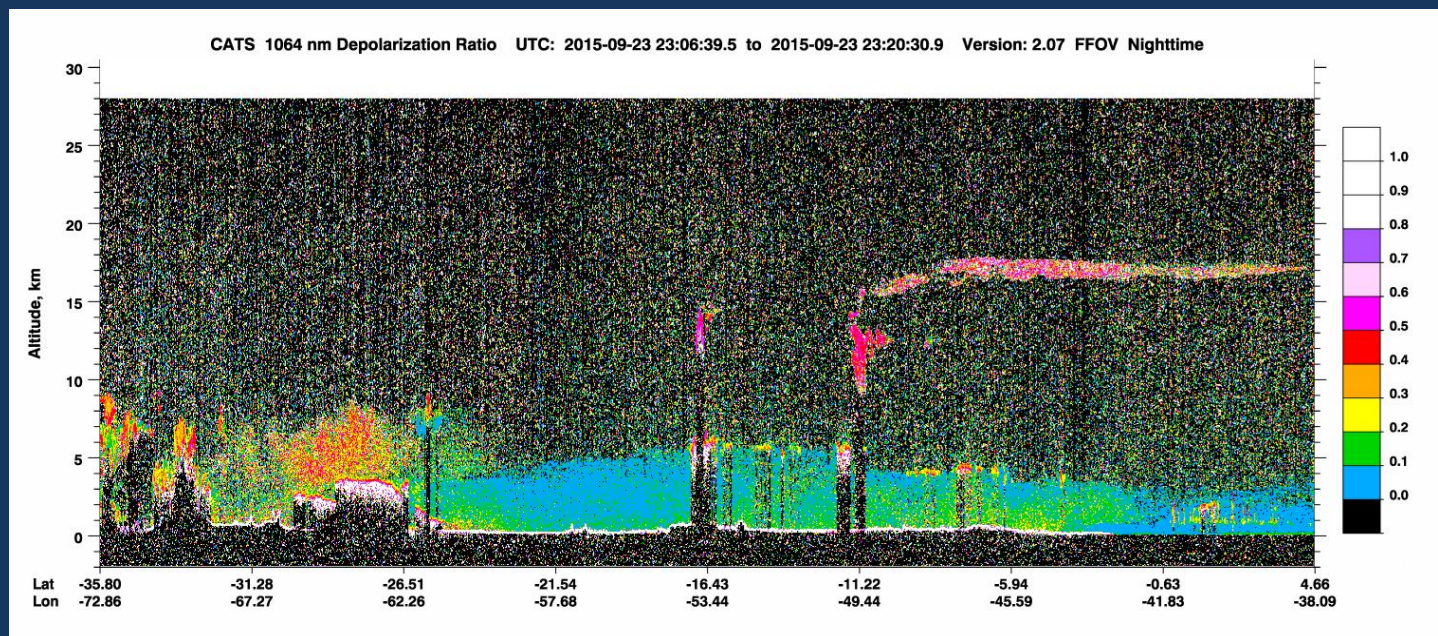
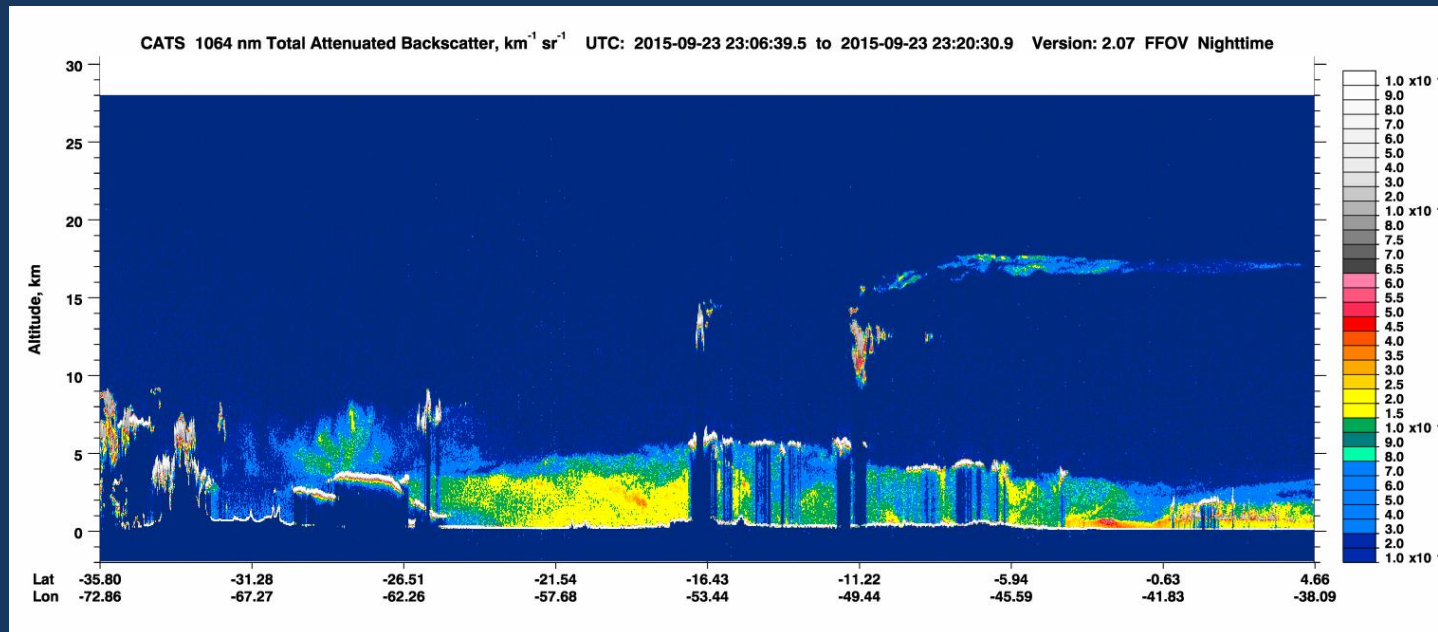
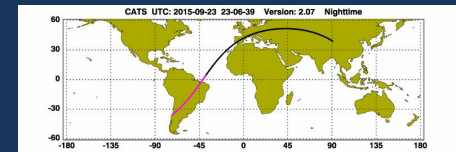


# Case Study: Saharan Dust



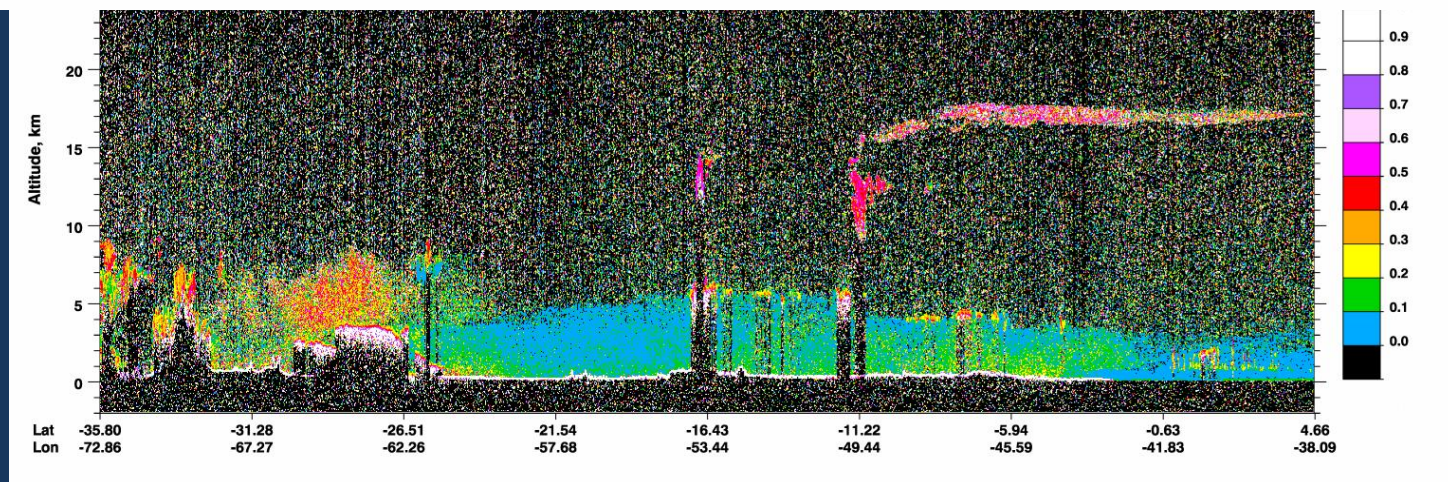
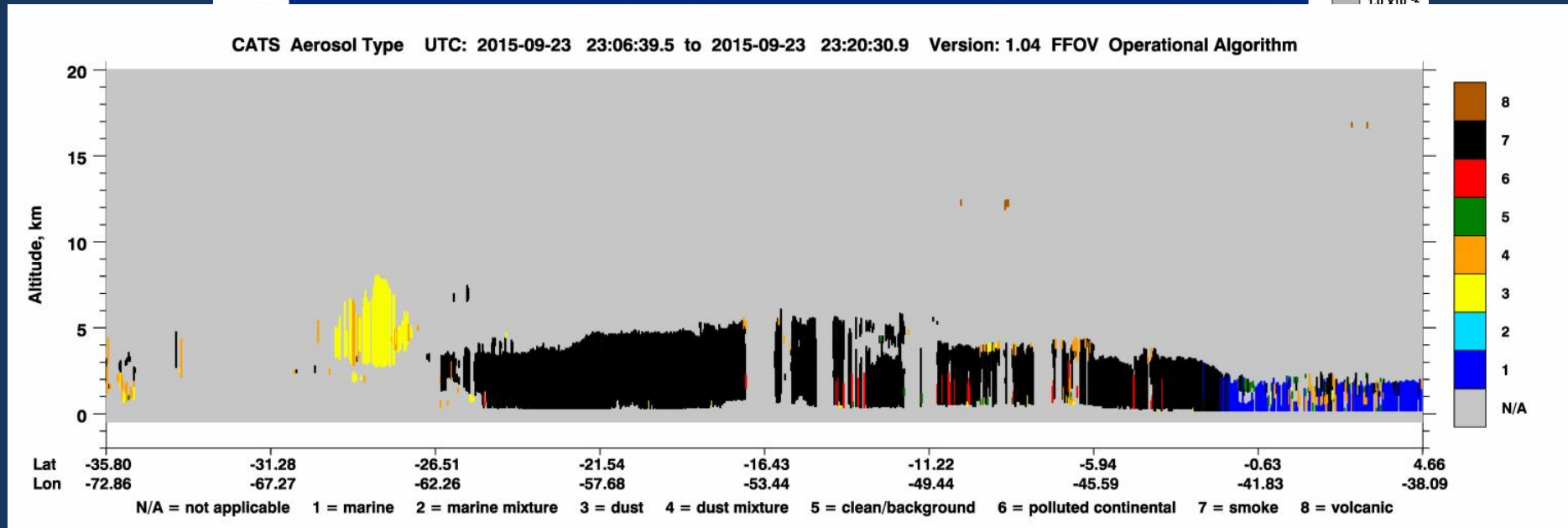
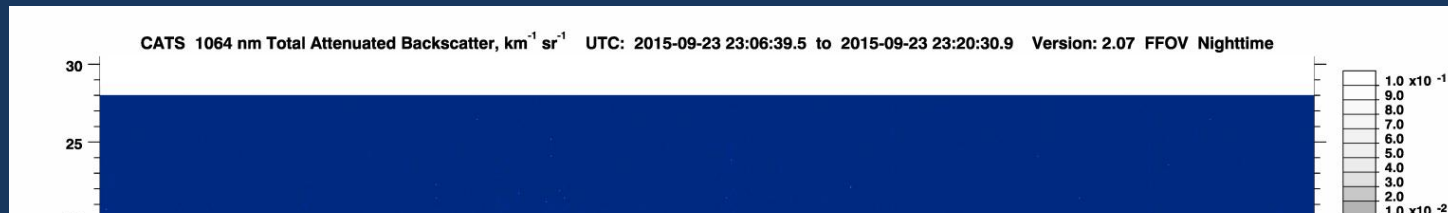
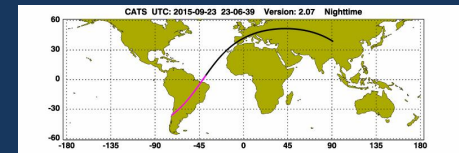


# Case Study: Smoke over South America



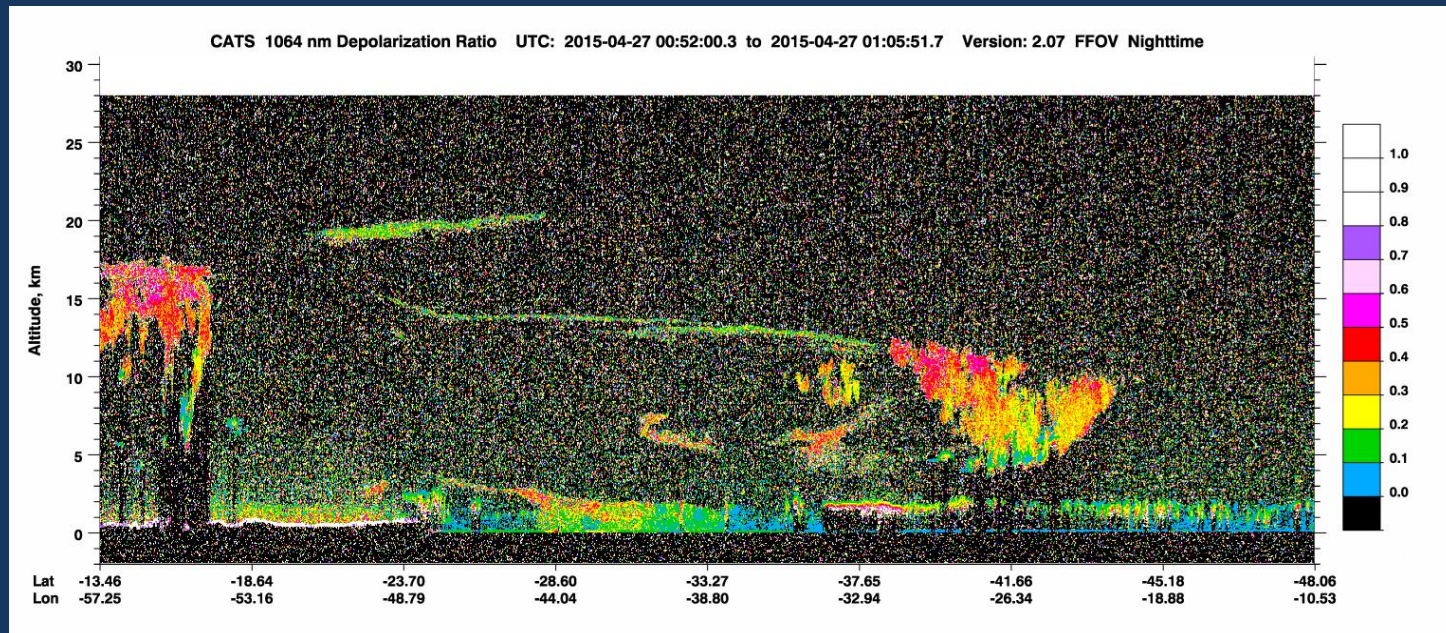
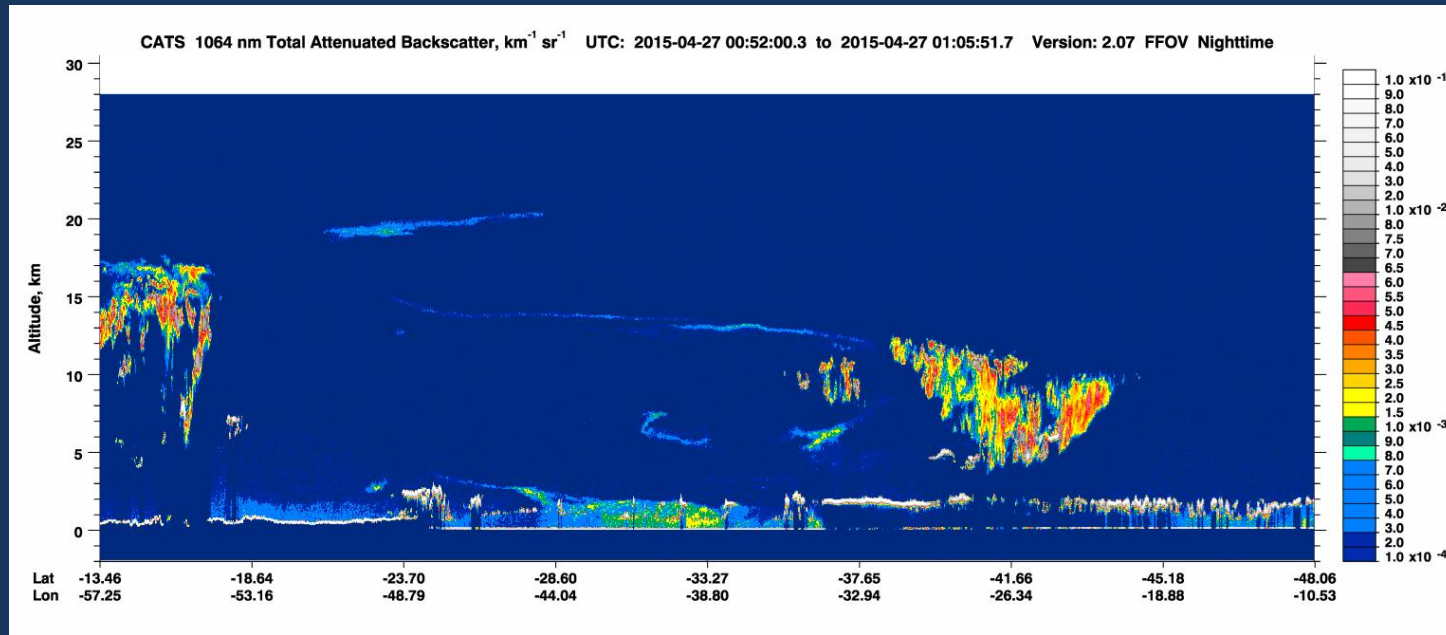
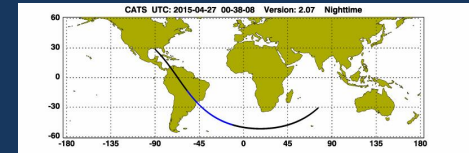


# Case Study: Smoke over South America



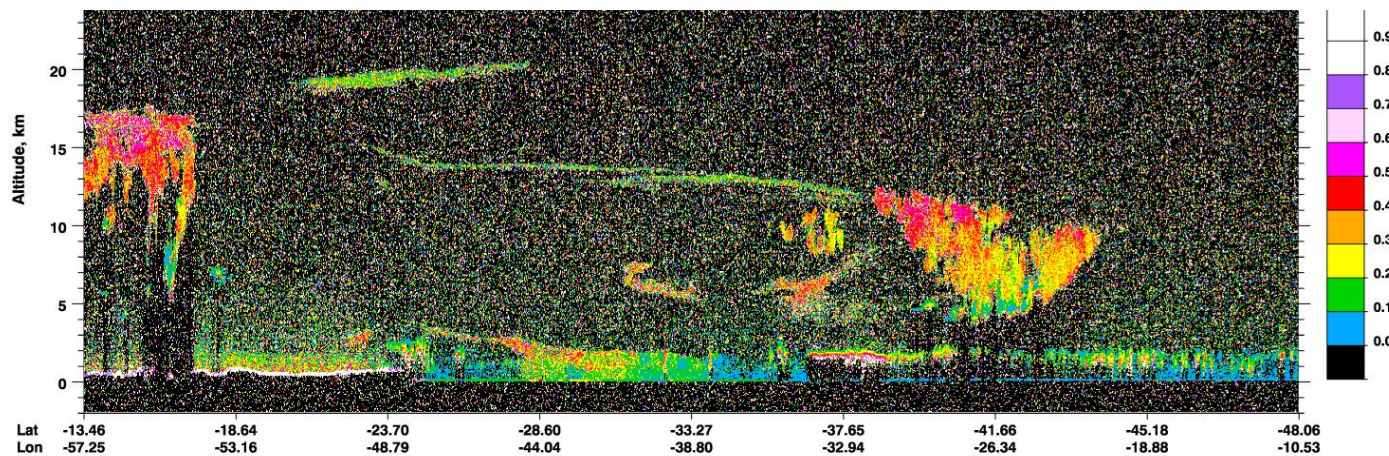
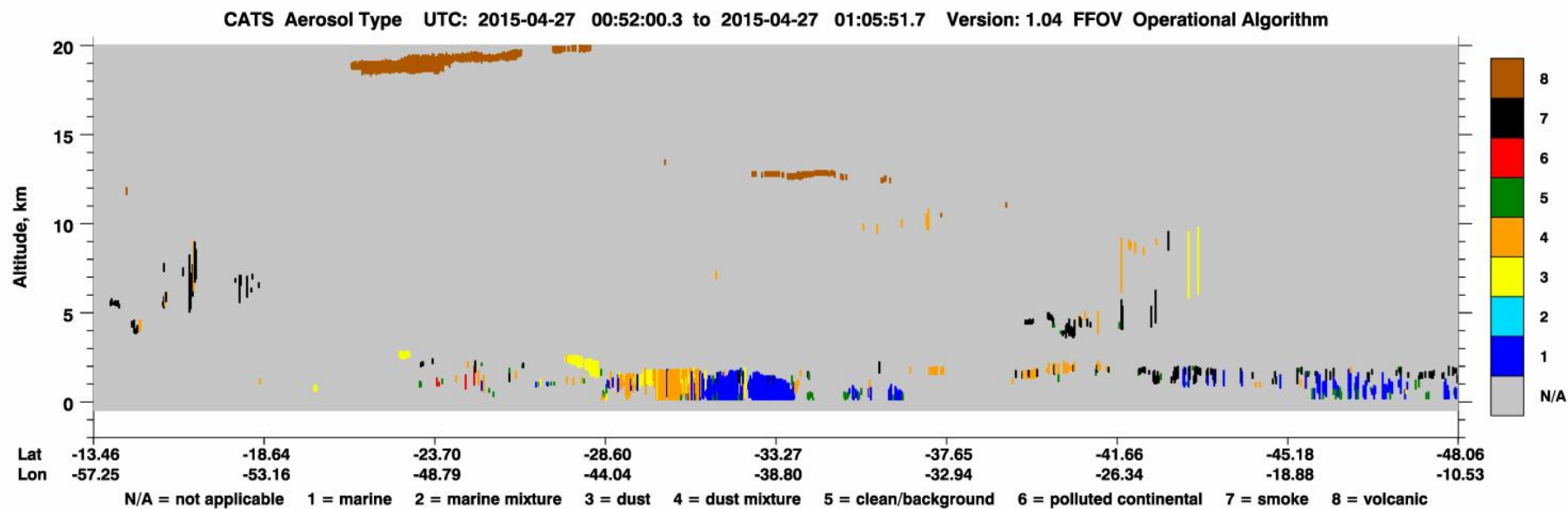
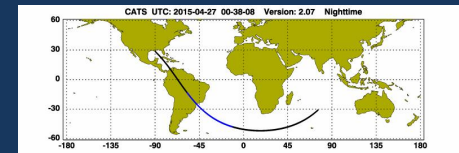


# Case Study: Calbuco Eruption



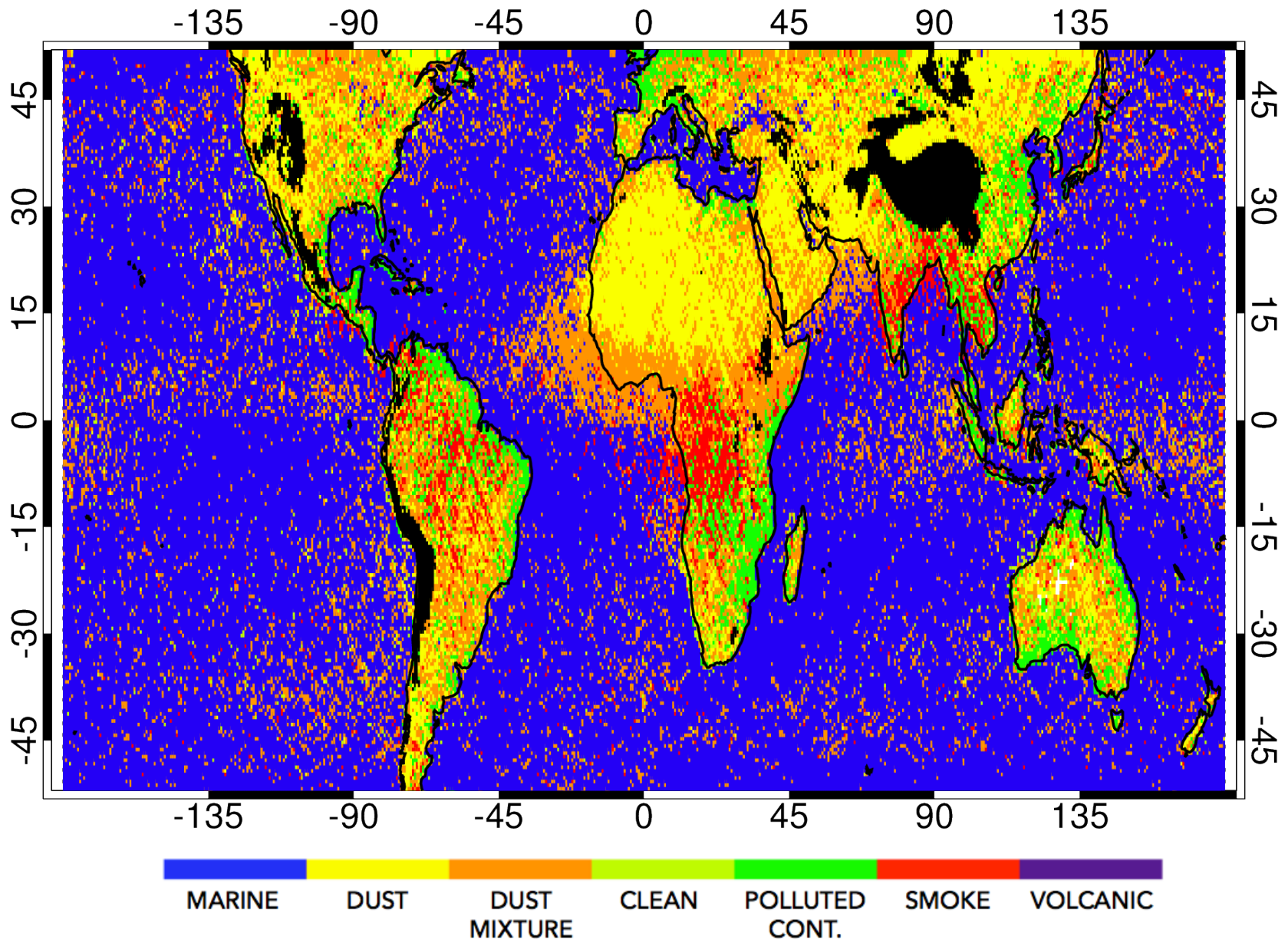


# Case Study: Calbuco Eruption

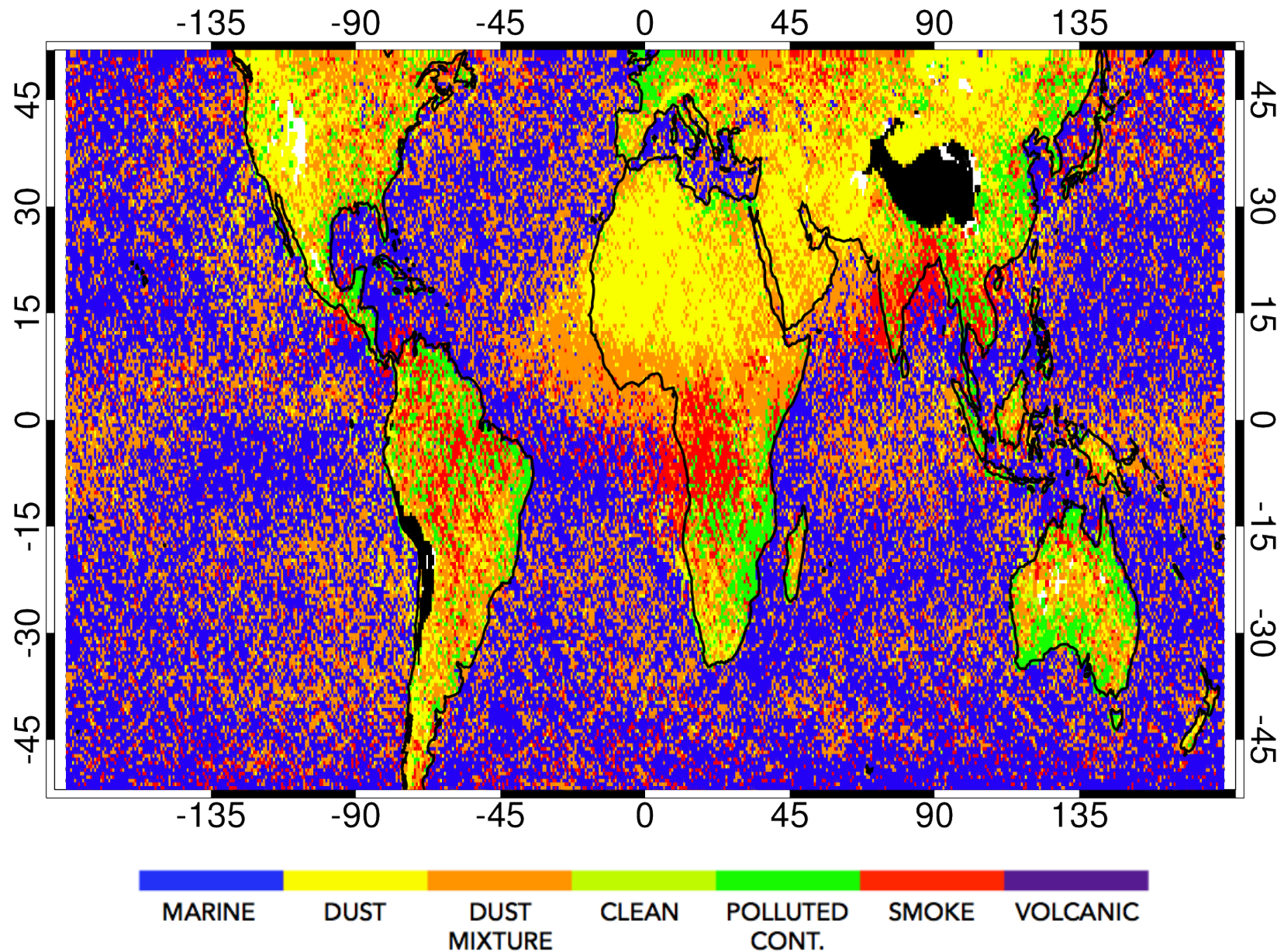




# March 2015 – Present Aerosol Typing [0 – 2 km]

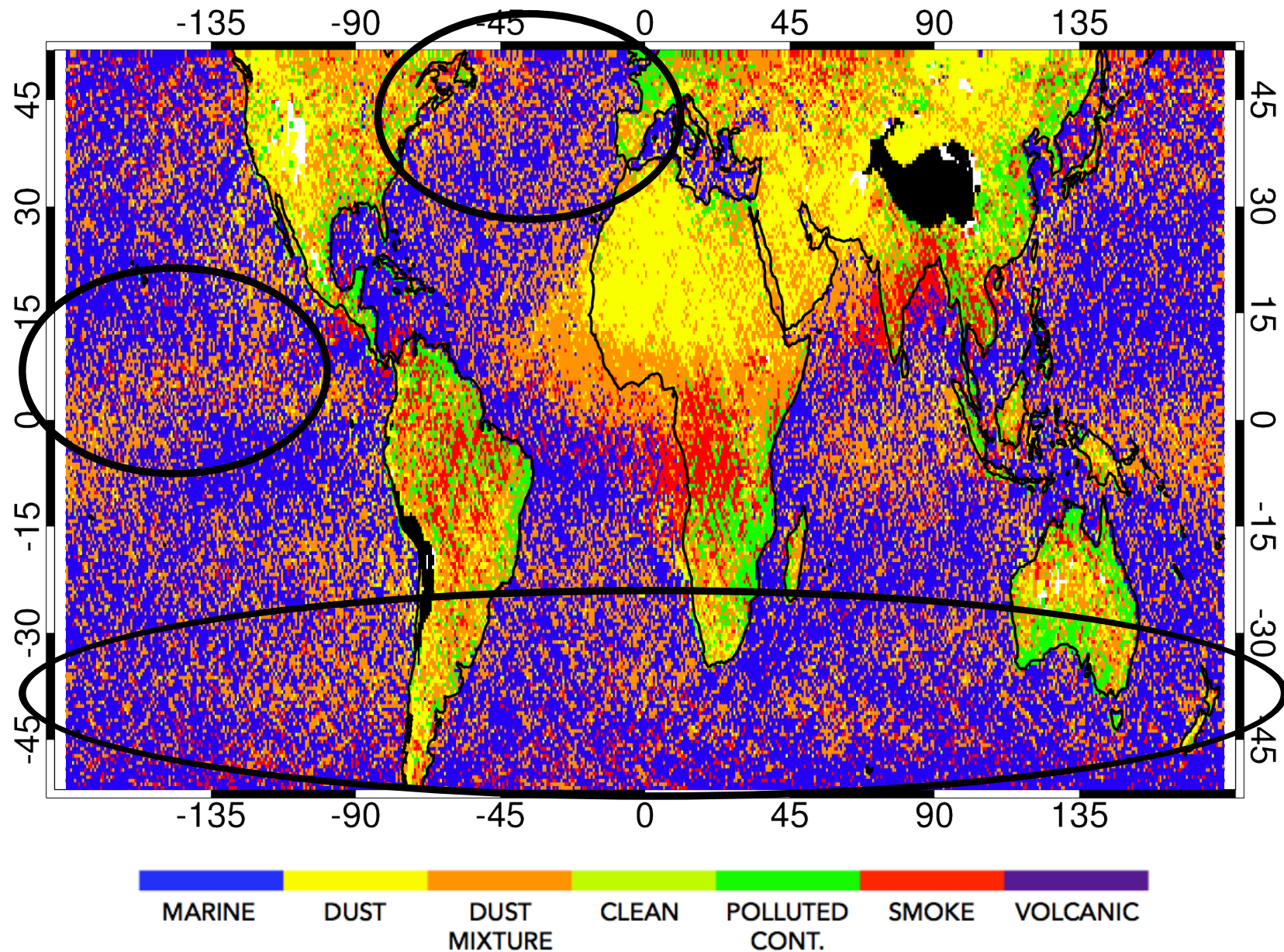


# March 2015 – Present Aerosol Typing [1 – 2 km]

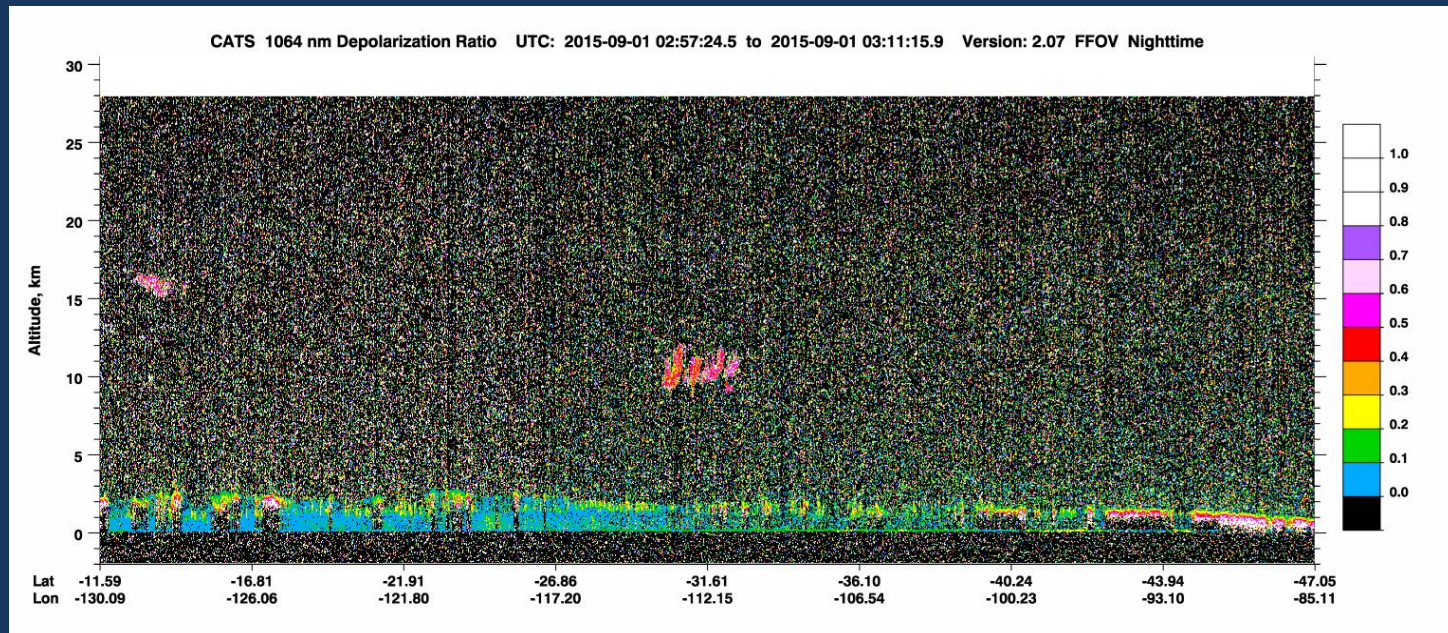
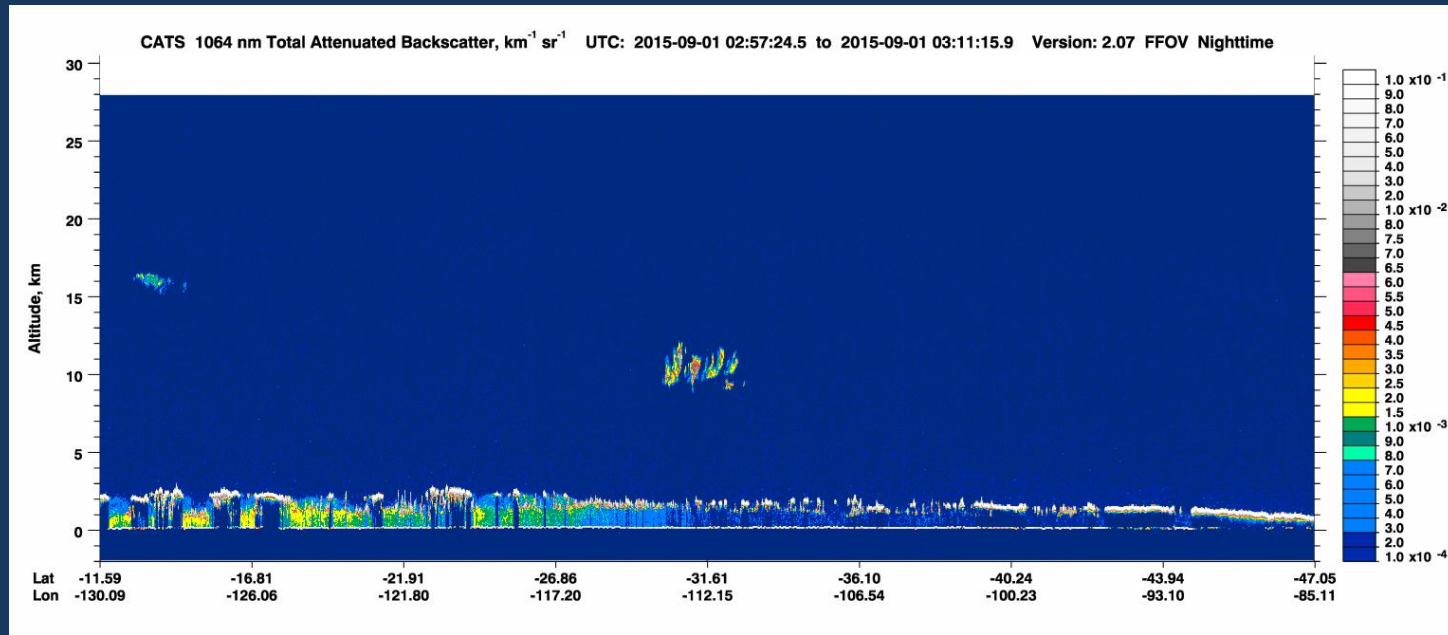
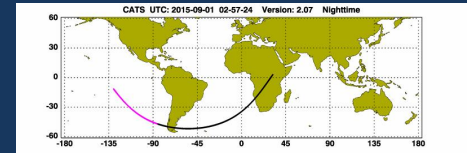




# March 2015 – Present Aerosol Typing [1 – 2 km]

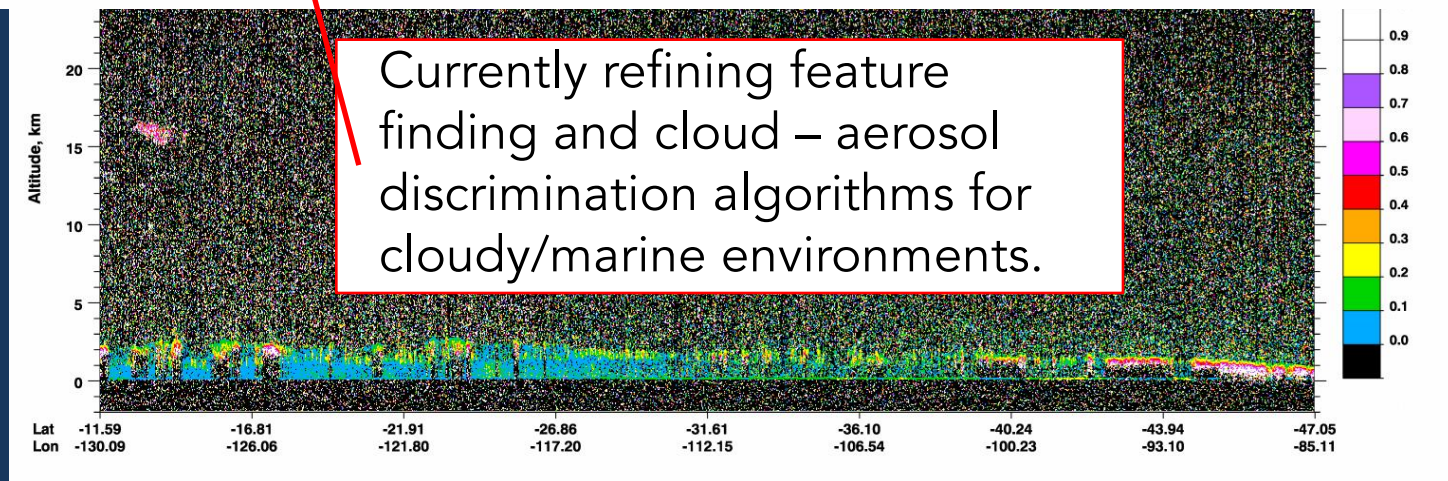
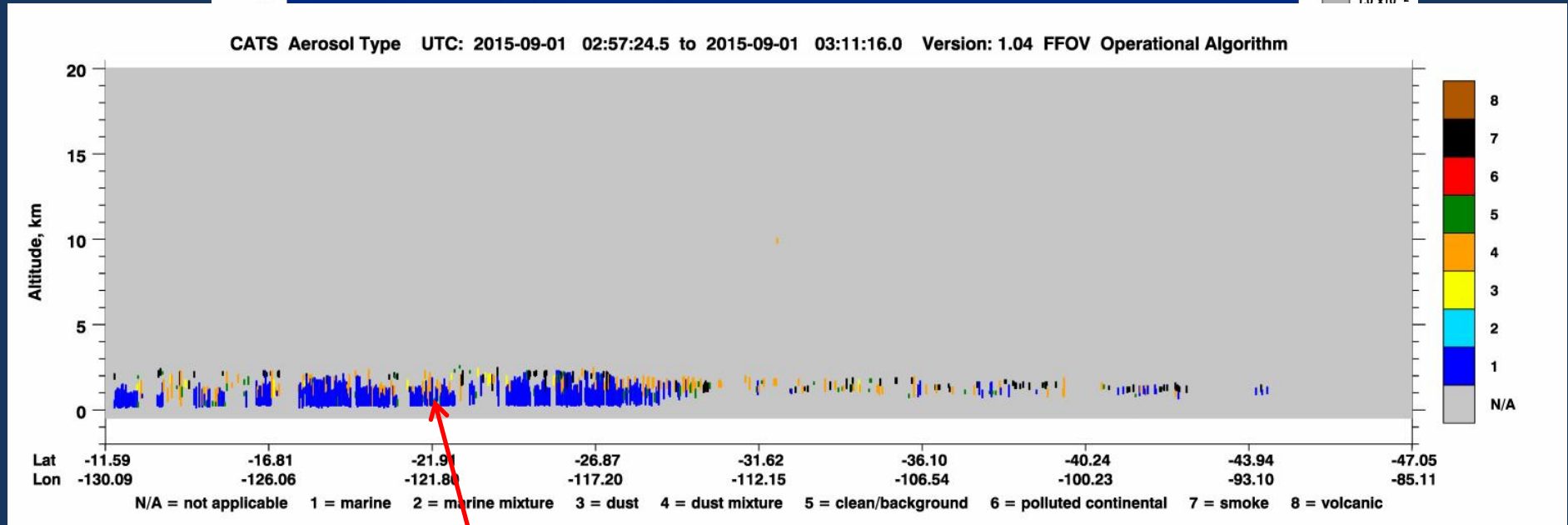
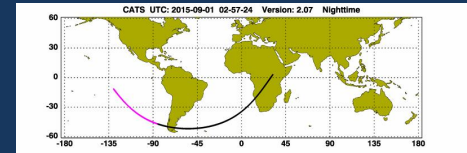


# Known Issues: High Frequency of Dust Layers

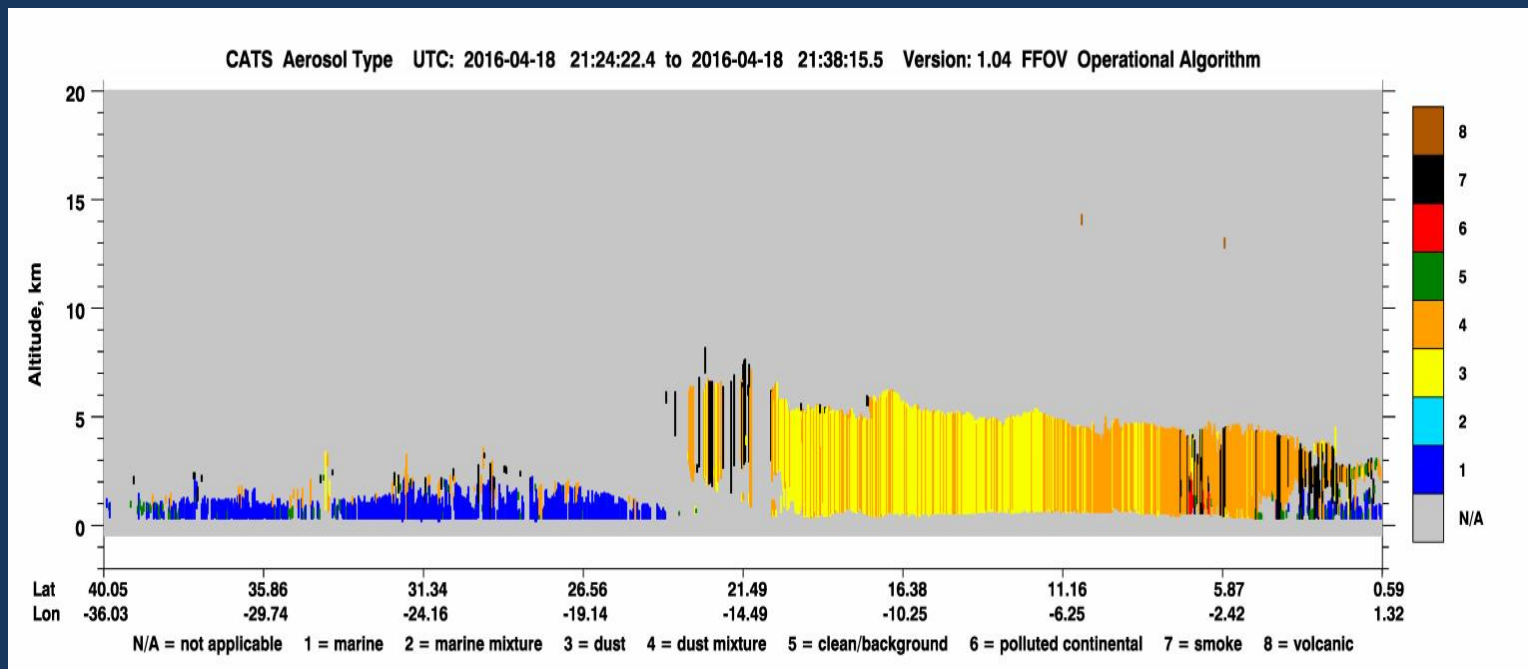
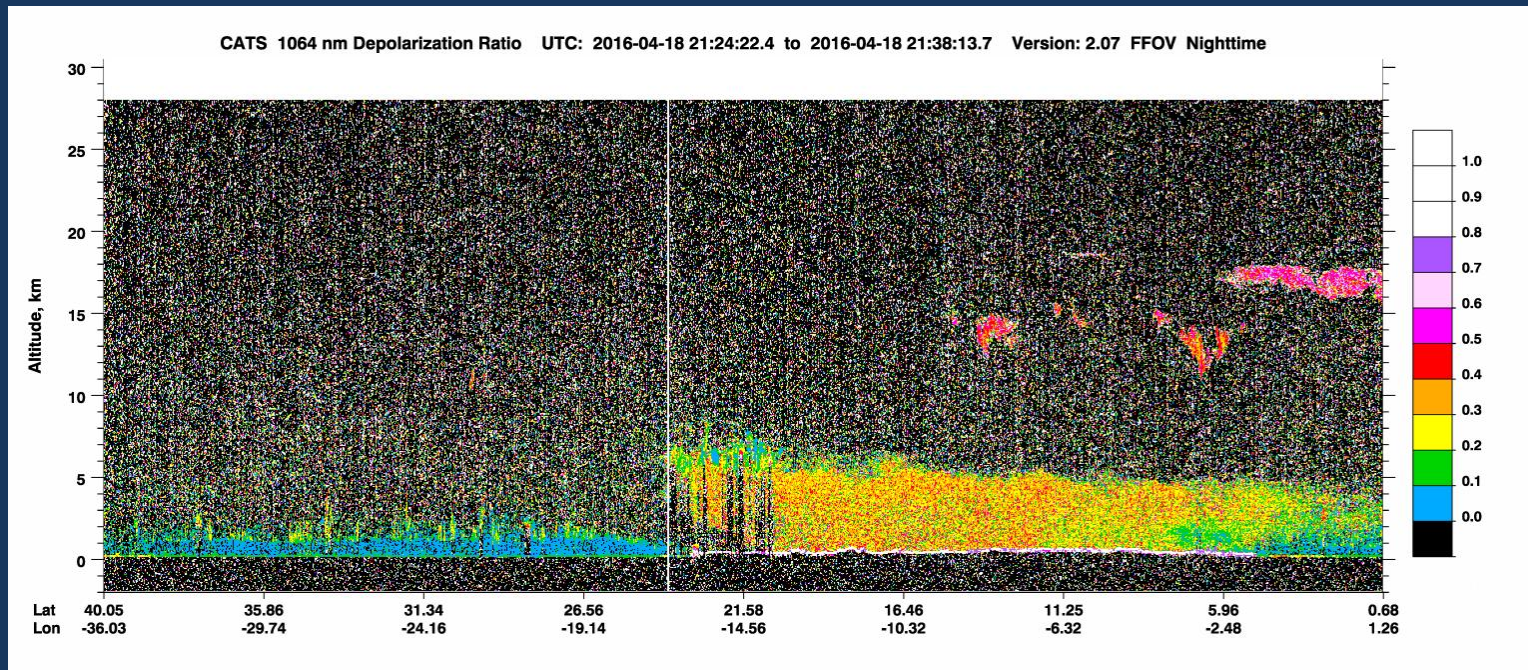




# Known Issues: High Frequency of Dust Layers



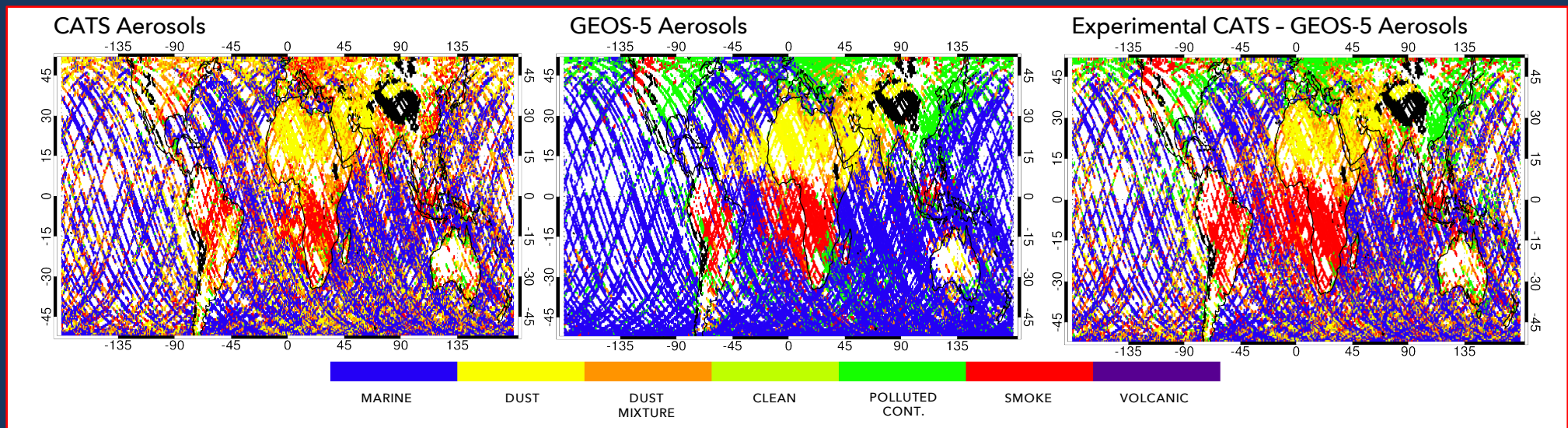
# Known Issues: "Striping" within Aerosol Layers





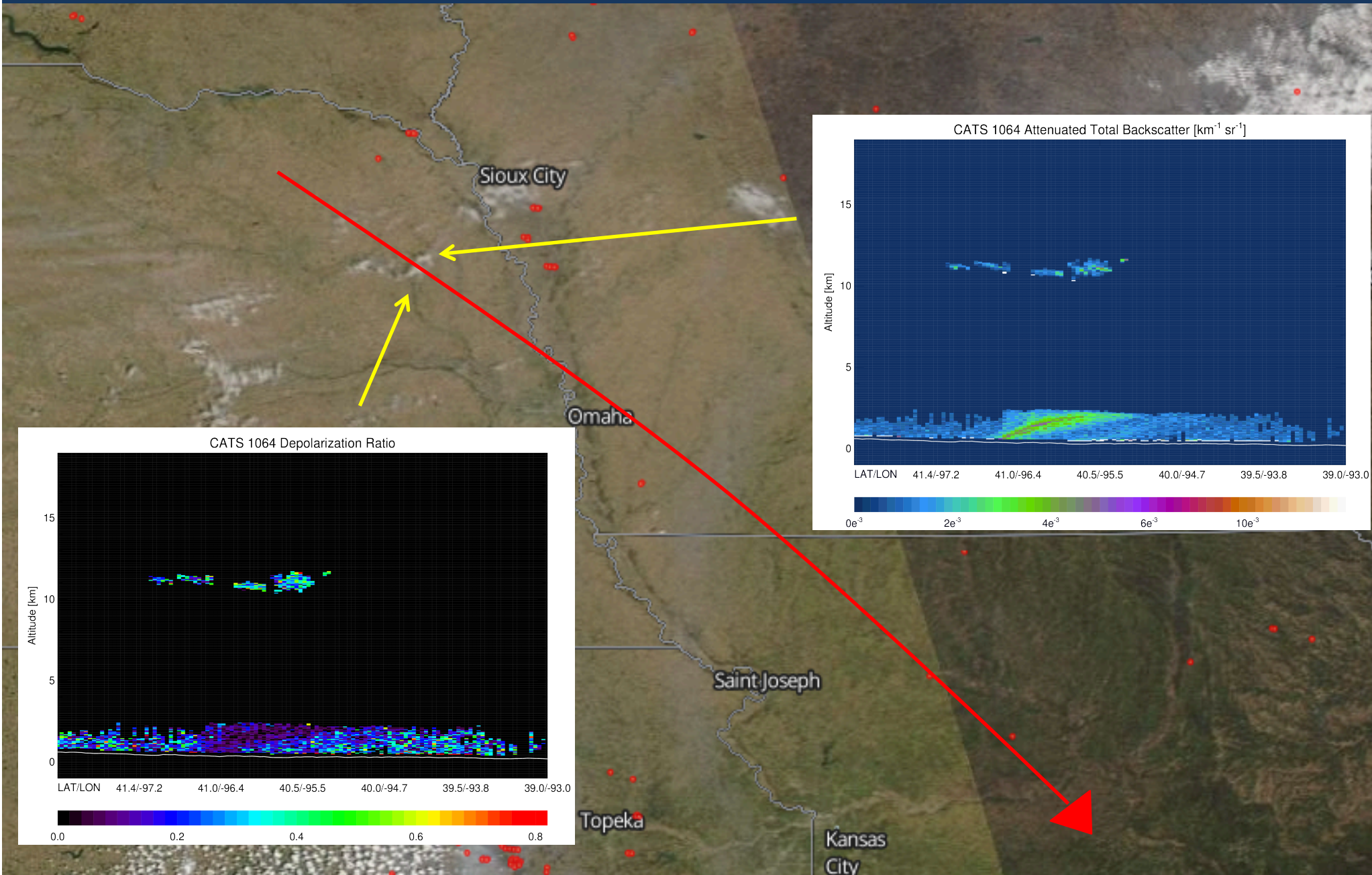
# Known Issues: Polluted Continental vs. Smoke Typing

- Differentiation between polluted continental and smoke type depends only on layer thickness and layer base altitude
- Can also lead to “striping” due to set thresholds in algorithm
- Plan to utilize simulated aerosols from the NASA GEOS – 5 AGCM to help classify non – depolarizing aerosol types
  - Aerosol Climatology (ex. MERRA2)
  - 1-D Var Assimilation (in development)



# Challenges: Depolarizing Smoke

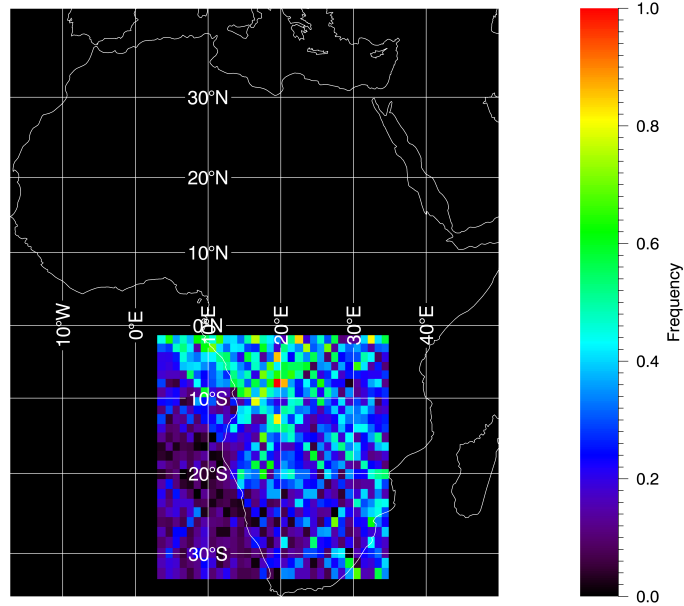
- Active Fires over Nebraska on 4/14/16



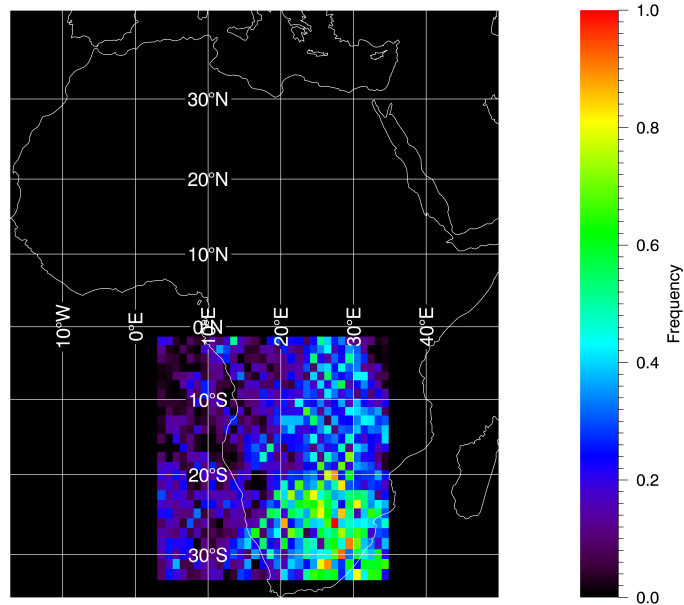


# Challenges: Depolarizing Smoke

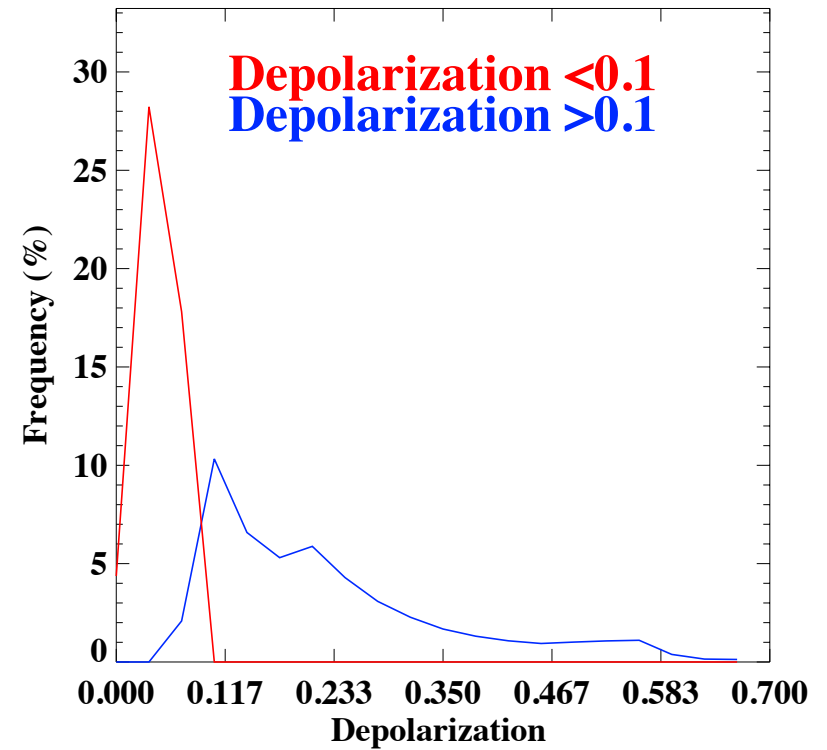
CATS Non-Spherical Smoke Detection Frequency: May-October 2015



CATS Spherical Smoke Detection Frequency: May-October 2015



## CATS Depolarization Ratio Frequency



Courtesy of N. Midzak

# CATS Mode 1 Overview

- Backscatter and Depolarization Ratio at 532 nm and 1064 nm
- 2 different fields of view (left + right)
- Utilize spectral depolarization ratio for aerosol typing

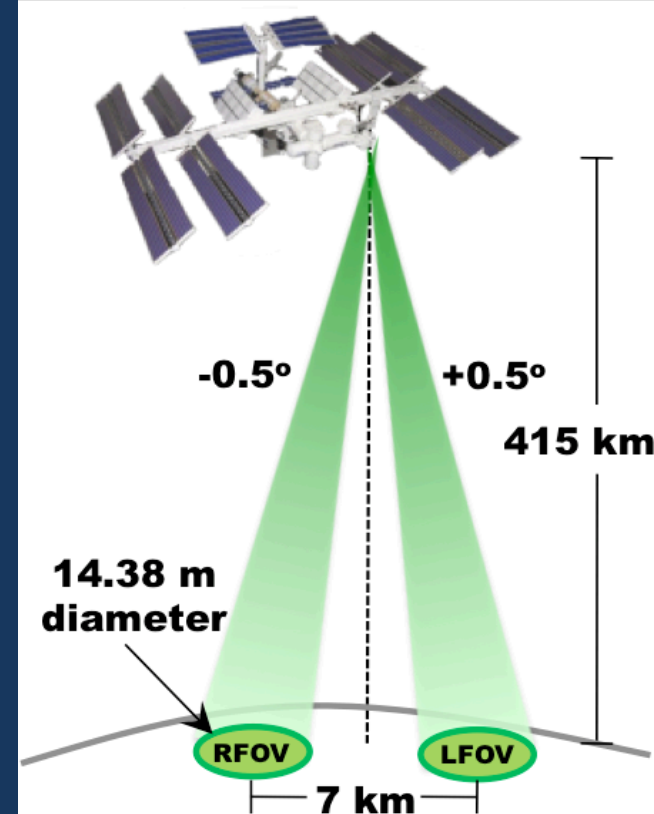
| Aerosol Type         | 532 nm Lidar Ratio | 1064 nm Lidar Ratio |
|----------------------|--------------------|---------------------|
| Marine               | 25                 | 45                  |
| Polluted Marine      | 45                 | 40                  |
| Dust                 | 45                 | 55                  |
| Dust Mixture         | 35                 | 45                  |
| Clean/Background     | 55                 | 35                  |
| Polluted Continental | 65                 | 35                  |
| Smoke                | 70                 | 40                  |
| Volcanic             | 45                 | 35                  |

## Mode 1: Multi-Beam

Backscatter: 532, 1064 nm

Depolarization: 532, 1064 nm

L2 Products: 532, 1064 nm



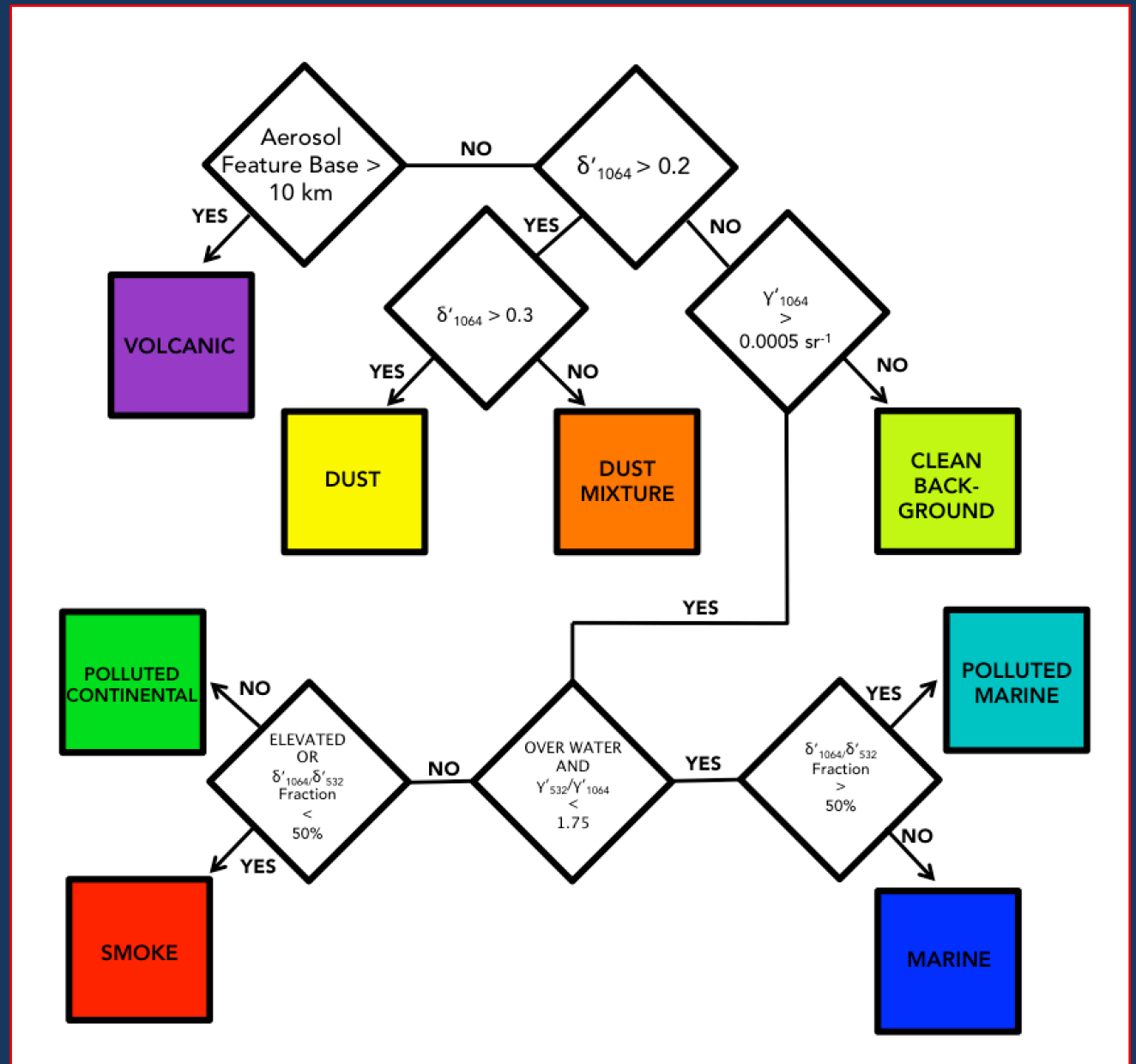
**Semi-continuous operation:**  
**Feb. 10 – Mar. 21 (2015)**



# CATS Mode 1 Aerosol Typing Algorithm

## Inputs:

- Feature Integrated Depolarization Ratio at 1064 nm ( $\delta'_{1064}$ ) averaged to 5 km horizontally
- Feature Integrated Total Attenuated Backscatter at 1064 nm ( $\gamma'_{1064}$ ) averaged to 5 km horizontally
- Surface Type (for maritime)
- Feature Altitude
- Feature Integrated Spectral Depolarization Ratio



# Status of CATS Level 2 and Plans for the Future:

## Version 1 Aerosol Typing (ongoing):

- Mode 1:
  - L1B data released later this summer
  - L2 data released shortly after
    - Identify algorithm biases (ex. striping, FOV biases)
- Mode 2:
  - Processed & Released
    - Currently working on correcting algorithm issues

## Version 2 Aerosol Typing (Fall, 2016):

- Implementation of version 1 modifications
- Integrate GEOS-5 aerosols for typing guidance for non – spherical aerosols

## Version 3 Aerosol Typing (2017):

- Implementation of 1-D Var Assimilation into GEOS-5
  - “Dynamic” lidar ratio that will evolve in conjunction with simulated aerosol mixtures



# Field Campaign Support:

April – May, 2016



June 2016 - Present



Starting Fall 2016

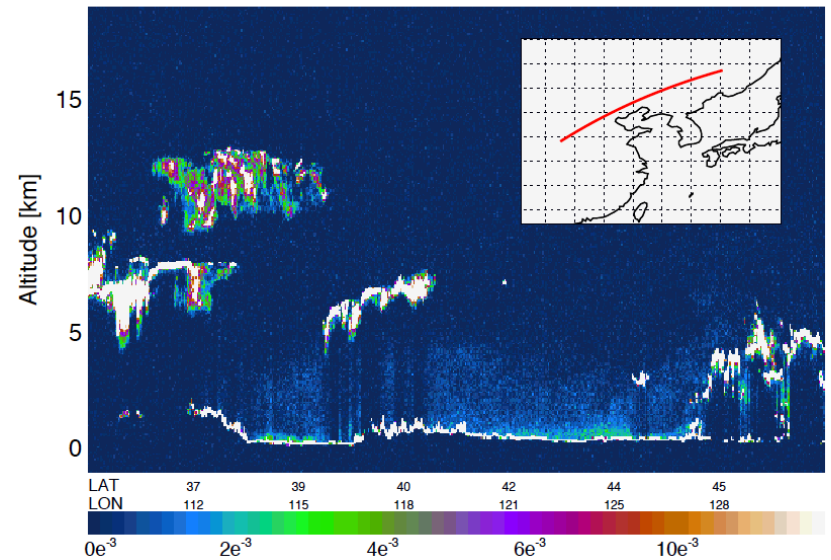


Contacts:

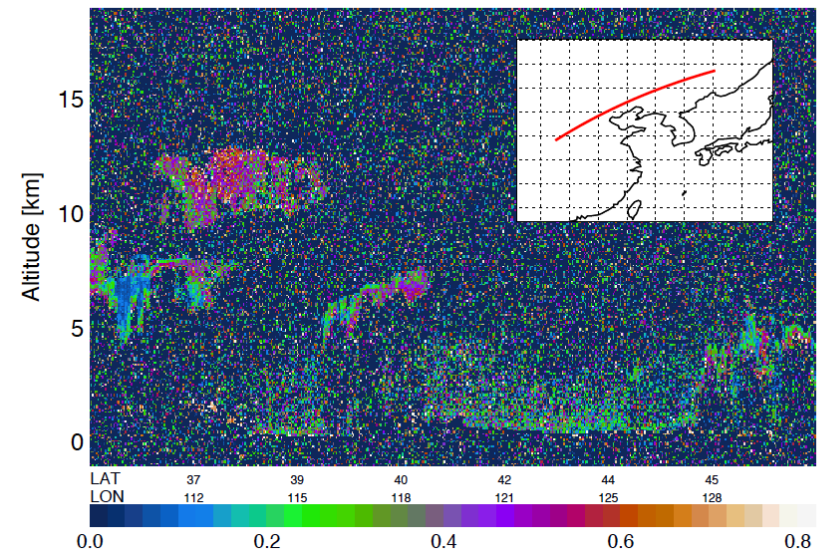
John Yorks – [john.e.yorks@nasa.gov](mailto:john.e.yorks@nasa.gov)

Ed Nowotnick – [edward.p.nowotnick@nasa.gov](mailto:edward.p.nowotnick@nasa.gov)

CATS 1064nm ATB 2016-05-25T13-41-06T14-25-33UTC



CATS 1064nm DEPOL 2016-05-25T13-41-06T14-25-33UTC



# Getting CATS Data:

<https://cats.gsfc.nasa.gov>

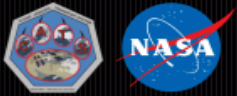
Cloud-Aerosol Transport System (CATS)

[Home](#)

[Project](#) ▾

[Science](#) ▾

[Contact](#)



## CATS

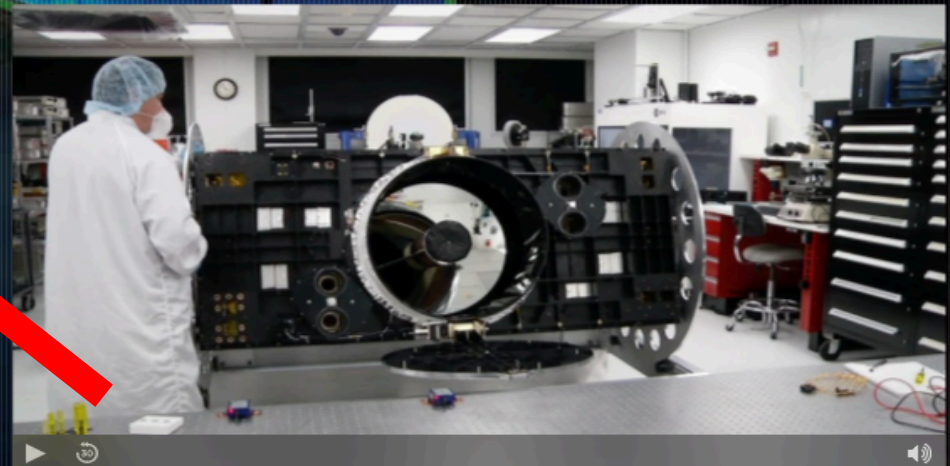
The Cloud-Aerosol Transport System (CATS), launched in January of 2015, is a lidar remote sensing instrument that will provide range-resolved profile measurements of atmospheric aerosols and clouds from the International Space Station (ISS). CATS is intended to operate on-orbit for at least six months, and up to three years.

[Operation Status](#)

[Data & Browse Images](#)

[Image of the Week](#)

[CATS Brochure \[PDF\]](#)

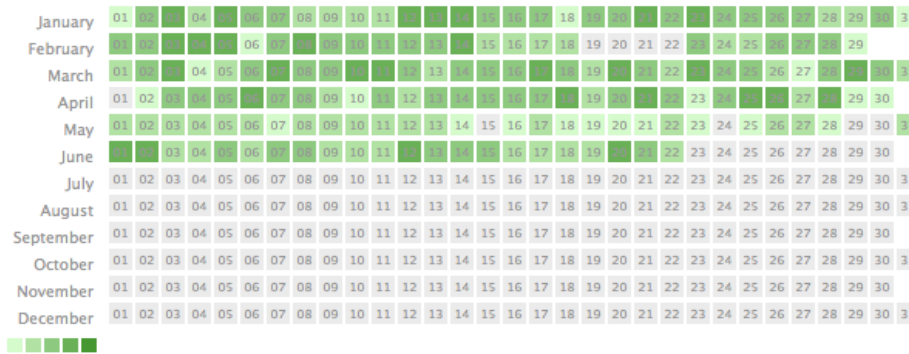




# Getting CATS Data:

<https://cats.gsfc.nasa.gov>

Granule  
Availability  
2016



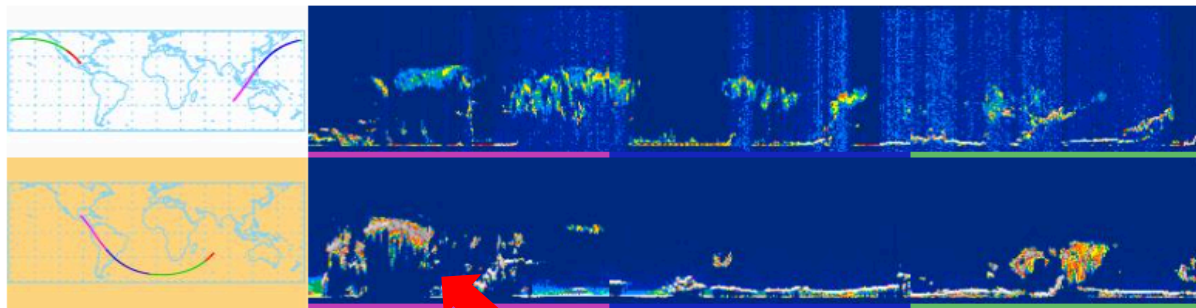
CATS data users, please note the instrument modes and data versions below:

- *Mode 7.1*: data from 10 Feb. through 21 March 2015, version 2-04 (V2.06 will be released shortly)
- *Mode 7.2*: data from 25 Mar. 2015 through present, version 2-06

2016-06-22

00:28 UTC

01:15 UTC



Quick Look  
Images

NRT HDF5 Files

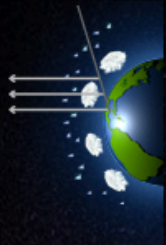


HDF5▼

Lidar Level 2 Operation Layer DP  
Lidar Level 2 Operation Profile DP  
Lidar Level 1B

# Getting CATS Data:

<https://eosweb.larc.nasa.gov/project/cats/>



**Atmospheric  
Science  
Data Center**

Processing, archiving and distributing Earth science data  
at the NASA Langley Research Center

 [Home](#)[Data Descriptions](#)[Order Data](#)[Citing ASDC Data](#)[Help & Resources](#)

[Home](#) » CATS Data and Information Page

## Cloud-Aerosol Transport System (CATS) Data and Information



The Cloud-Aerosol Transport System ([CATS](#)), is a lidar remote sensing instrument that will provide range-resolved profile measurements of atmospheric aerosols and clouds from the International Space Station (ISS).

CATS will provide vertical profiles at three wavelengths, orbiting between ~230 and ~270 miles above the Earth's surface at a 51-degree inclination with nearly a three-day repeat cycle. For the first time, it will allow scientist to study diurnal (day-to-night) changes in cloud and aerosol effects from space by observing the same spot on Earth at different times each day.

[Products](#)[Parameters](#)

| Product Level | Description  |
|---------------|--|
| Level 2       | L1B files that are run through the new operational CATS L2 algorithm, which will include new capabilities. Includes geophysical parameters, such as the vertical feature mask, profiles of cloud and aerosol properties and layer-integrated parameters. |
| Level 1B      | L1A data that have been calibrated, annotated with ancillary meteorological data, and processed to sensor units.   |